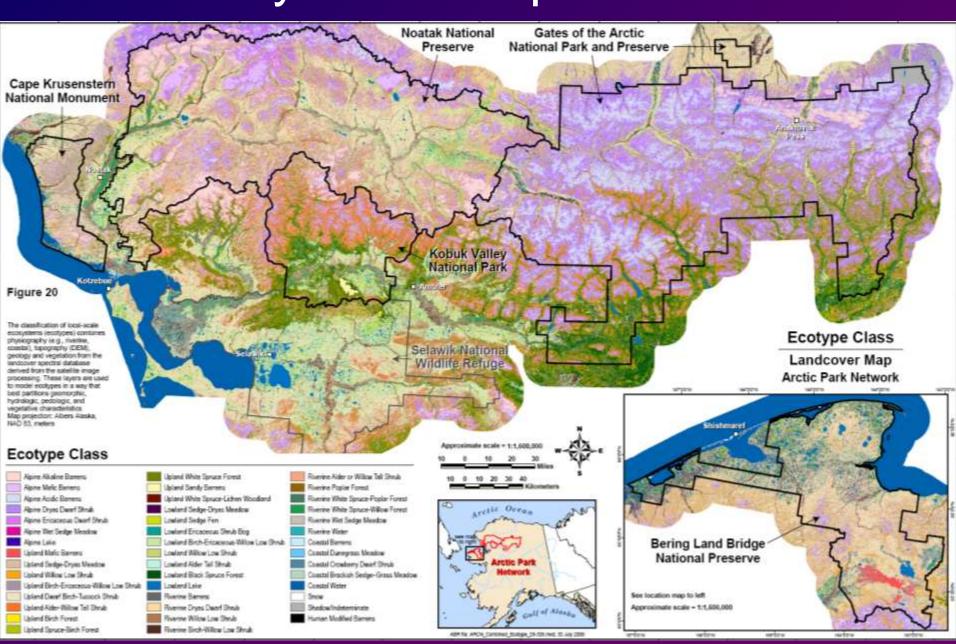


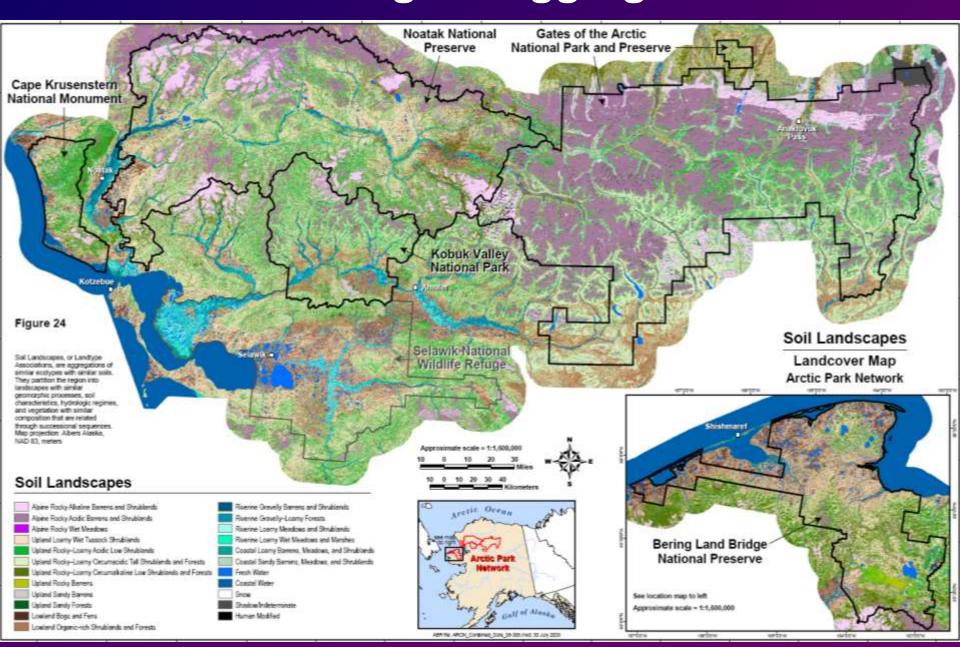
# **Assessment Approach**

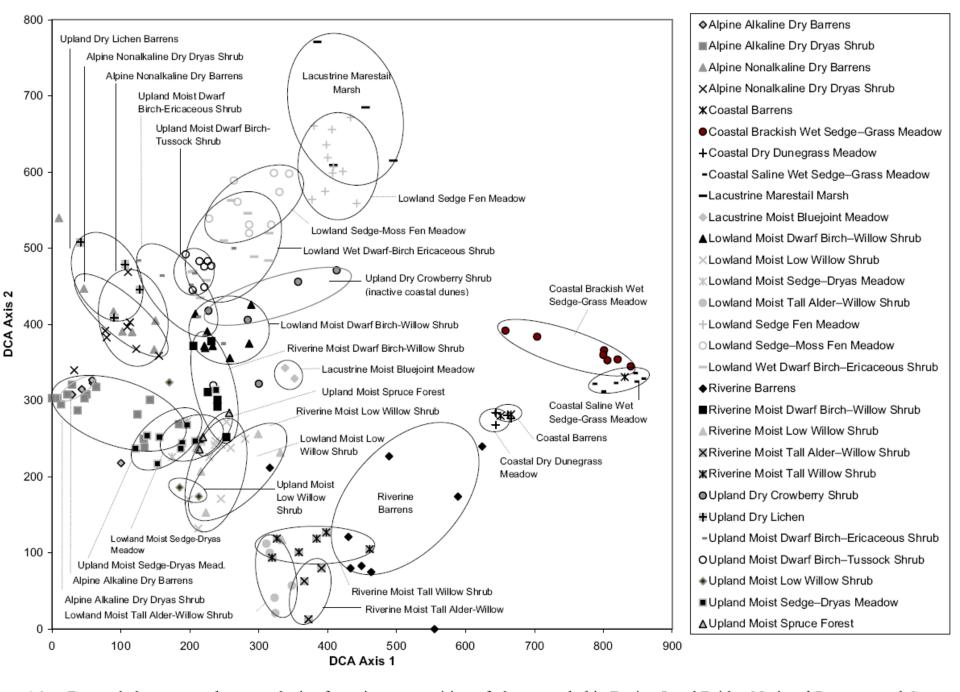
- Ecological Classification
  - Local and Landscape-Level Ecosystems
- Conceptual Modeling
  - Process and Pathway Models
- Monitoring (nice to have some field data)
- Landscape Change Analysis (time-series analysis of historical airphotos)
- General Predictions (Transition Probabilities)

## **Ecosystems Map for ARCN**



## **Ecological Aggregation**



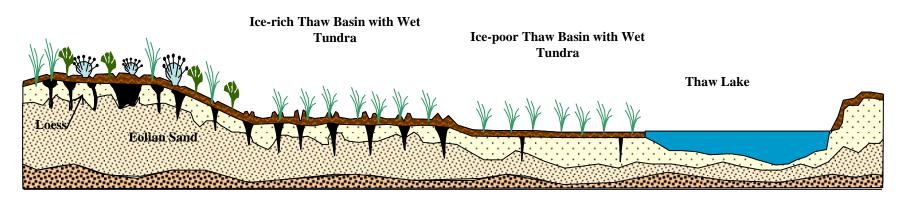


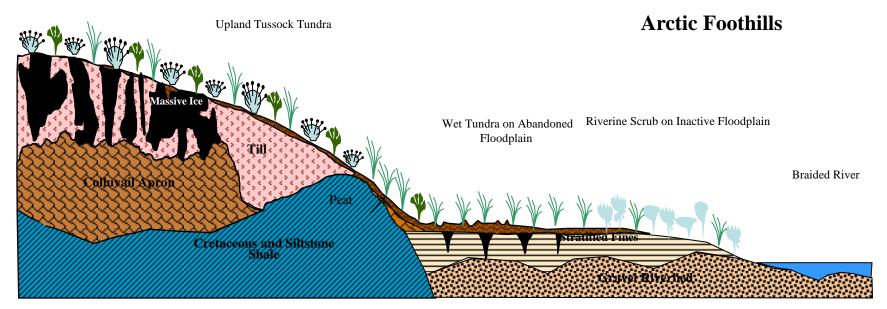
ure 16. Detrended correspondence analysis of species composition of plots sampled in Bering Land Bridge National Preserve and Cape Krusenstern National Monument, northwestern Alaska, 2002–2003. Ellipses depict central groupings of ecotypes.

#### **Arctic Landform-Vegetation-Permafrost Relationships**

**Arctic Coastal Plain** 

#### Coastal Plain with Moist/ Dry Tundra

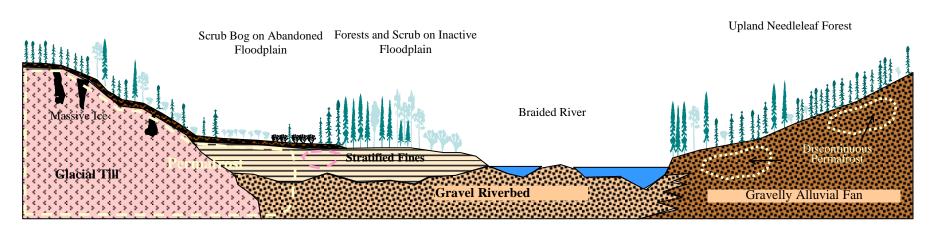




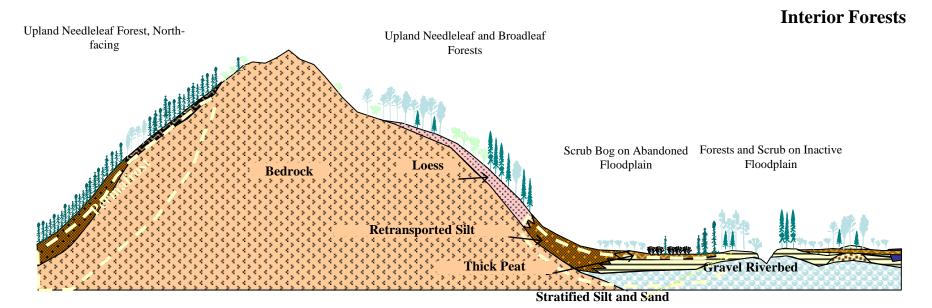
#### **Boreal Landform-Vegetation-Permafrost Relationships**

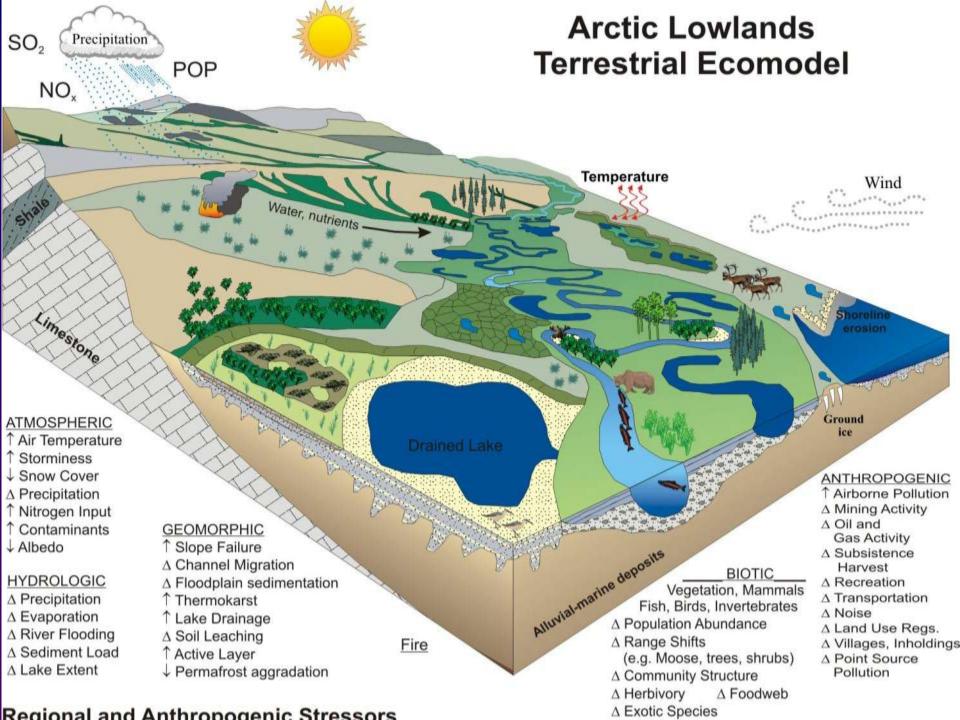
#### **Brooks Range**

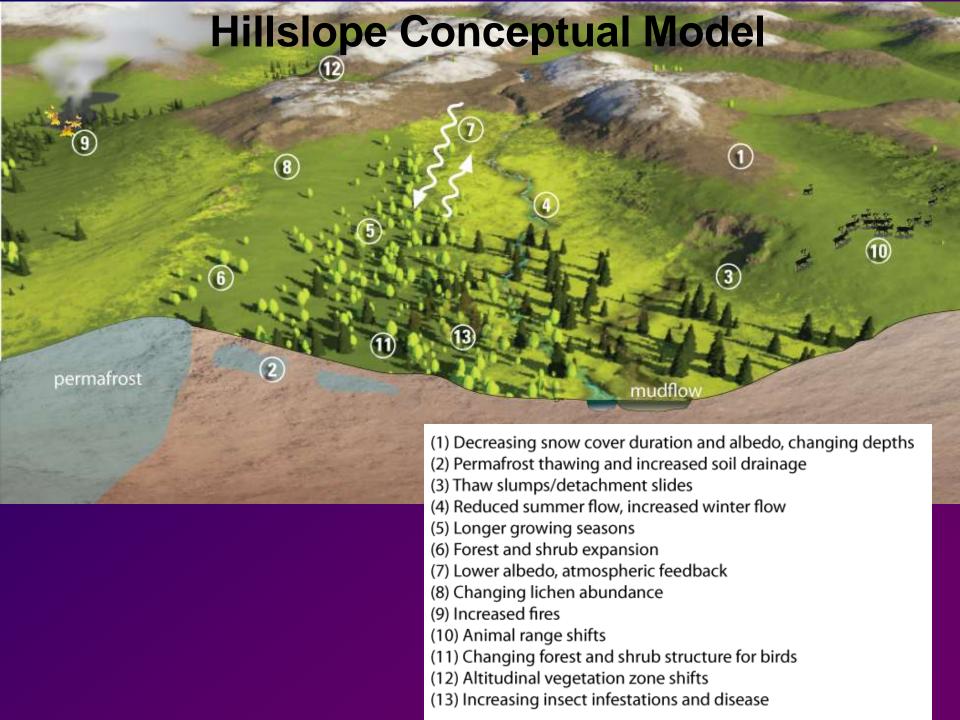
Upland Needleleaf Forest



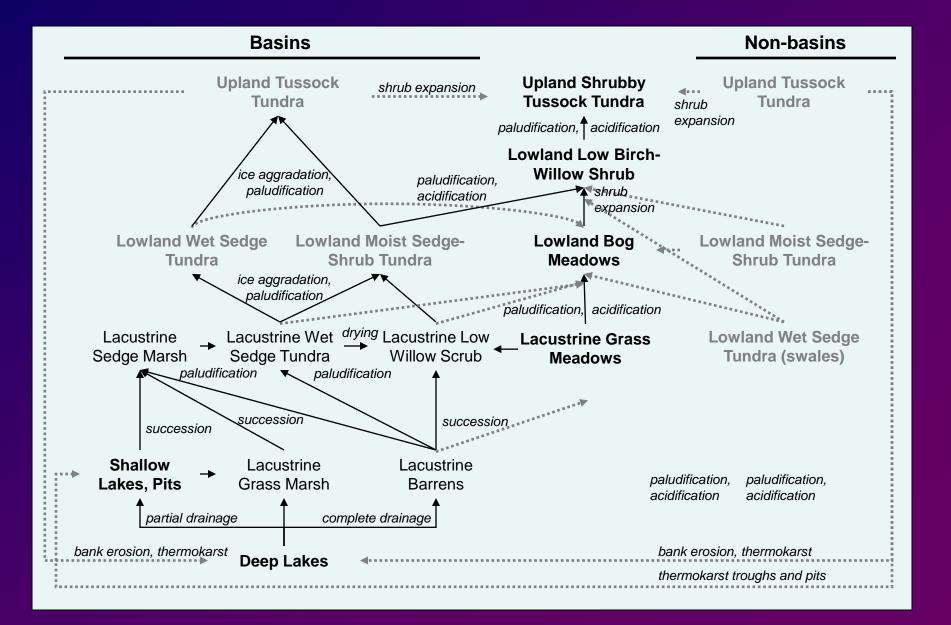
Alpine Tundra







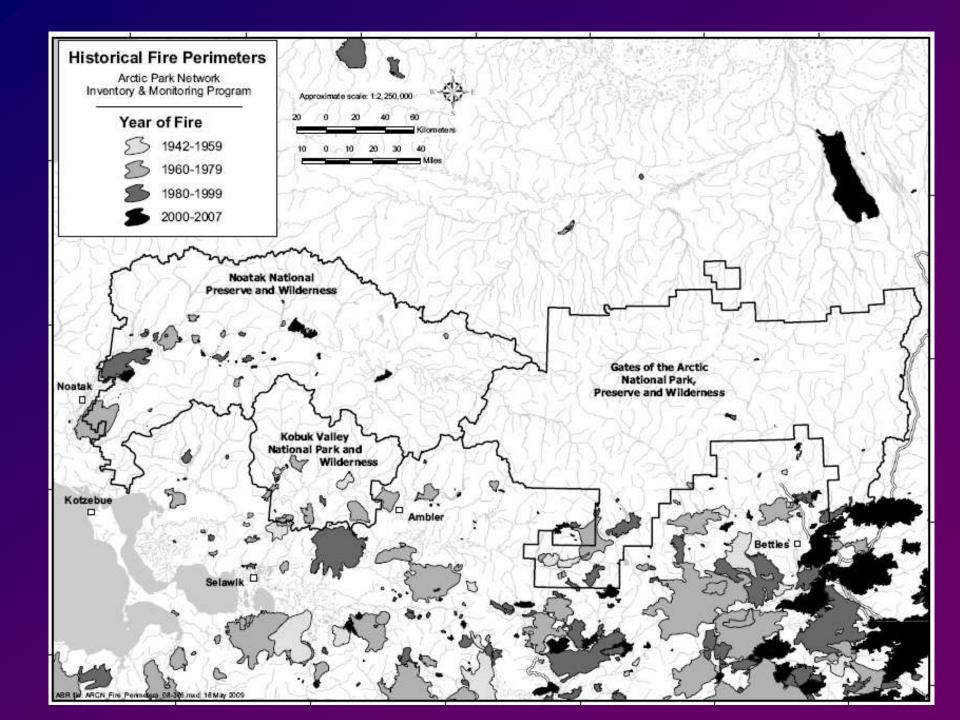
### **Coastal Plain Pathways**



## KEY PROCESSES

Thaw Lakes **Thaw Slump** Lake Drainage Landslides/Fans **Soil Drainage Drying Sedimentation Glacier melting** Fire **Acidification-leaching Paludification Primary succession Secondary succession Dominance shift Plant migration** Channel erosion **Coastal erosion Drainage/Migration Human development** Thaw settlement







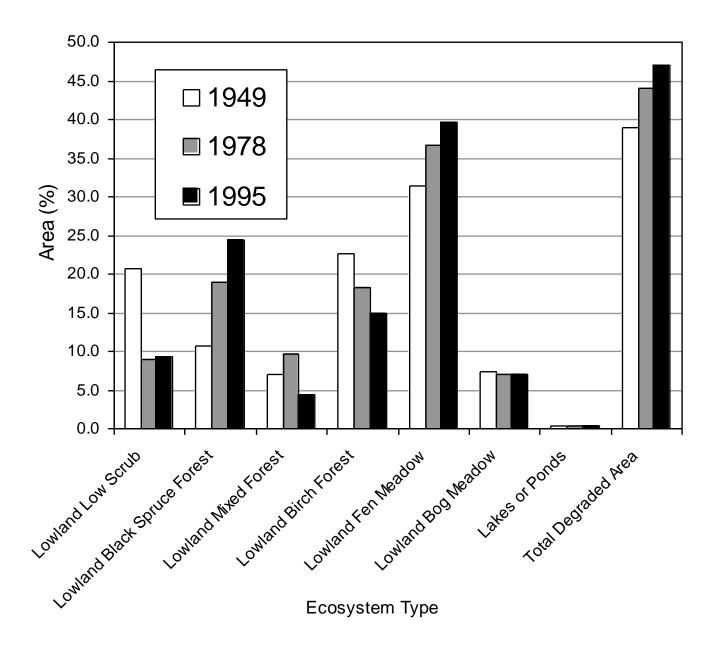


## **Historical Rates of Change**

1978 1995

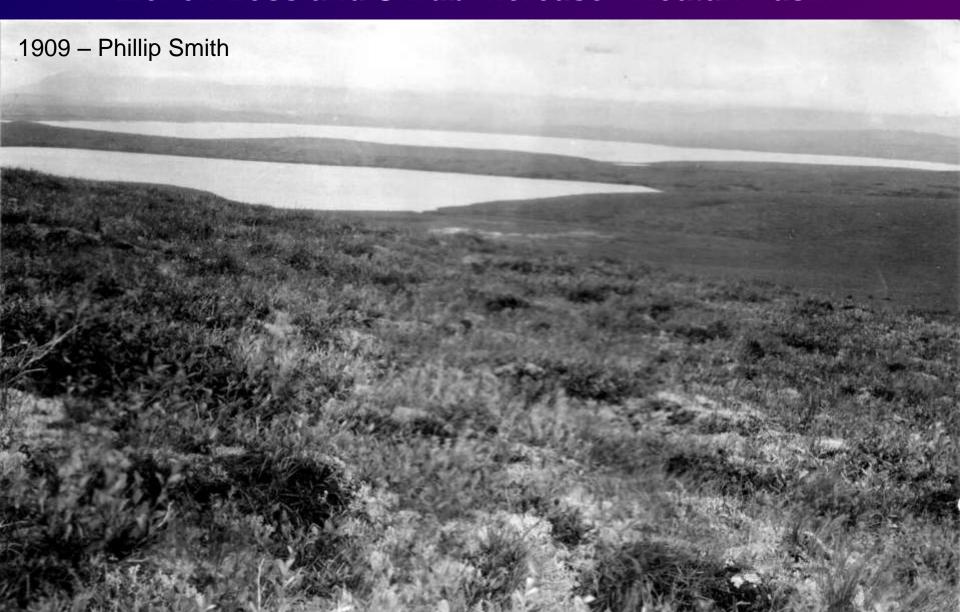




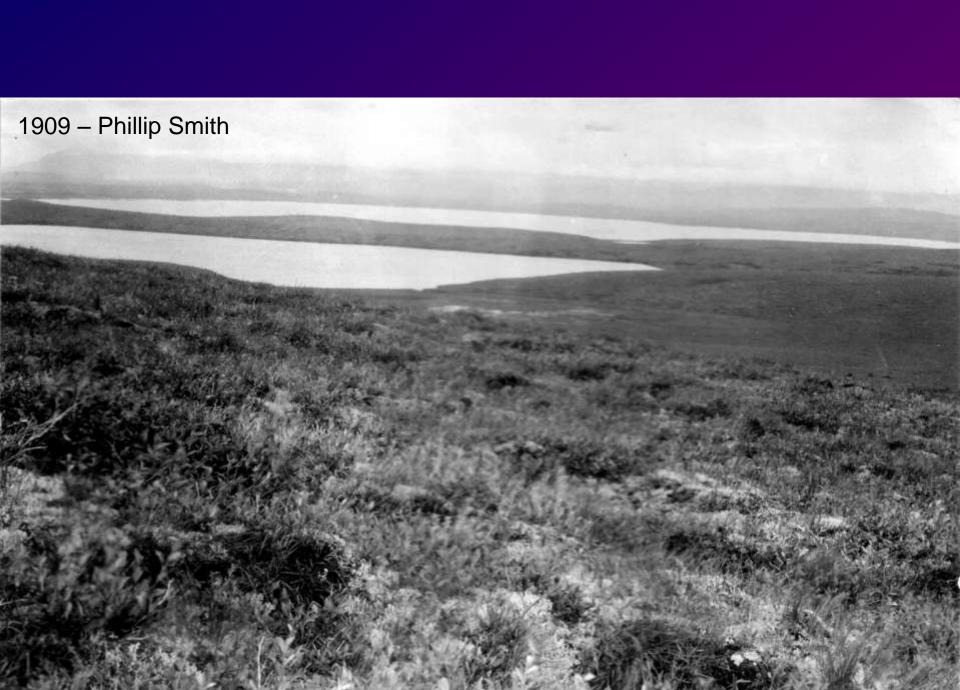


## Repeat Photography

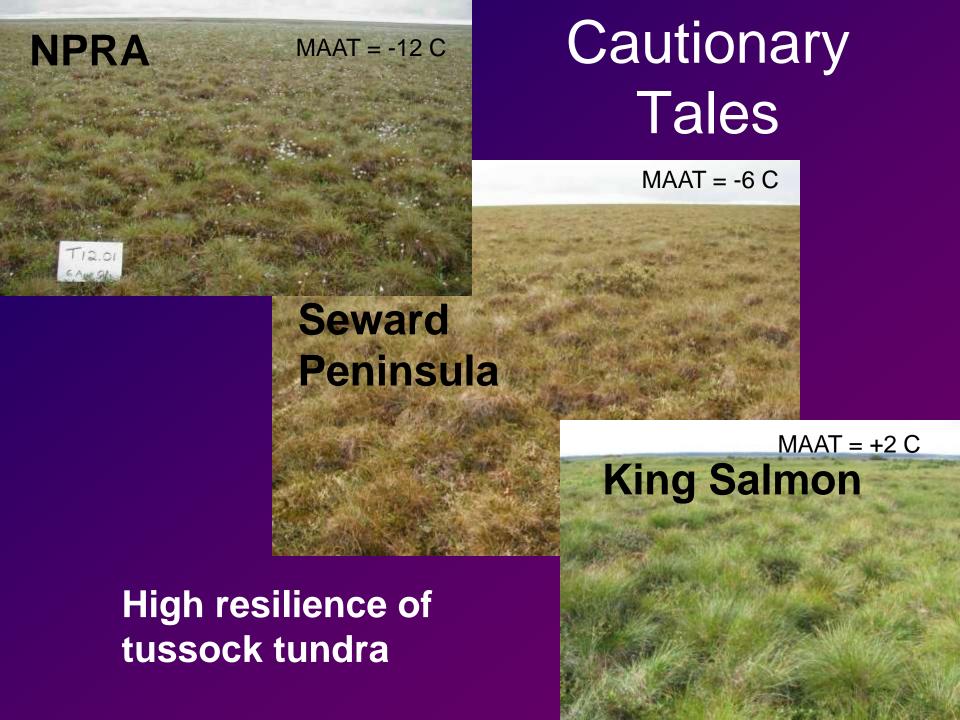
**Lichen Loss and Shrub Increase- Noatak Basin** 









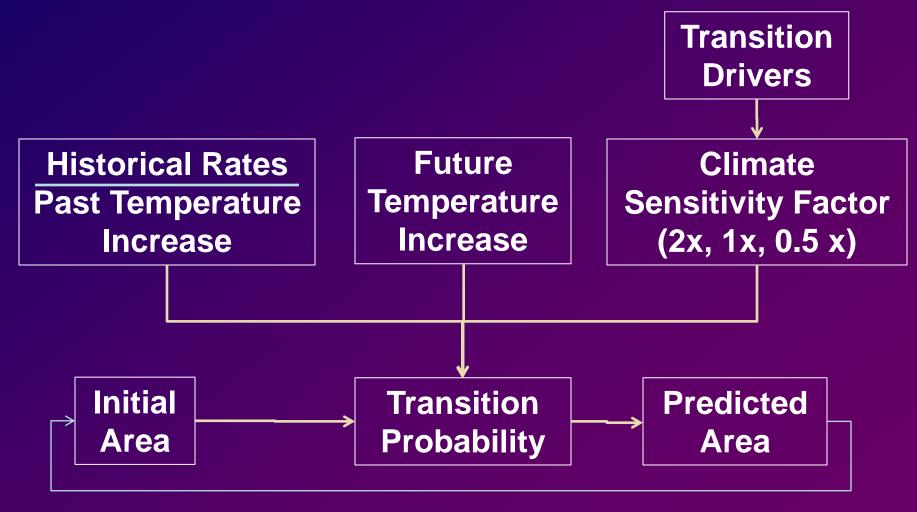


# Floodplains as Migration Corridors



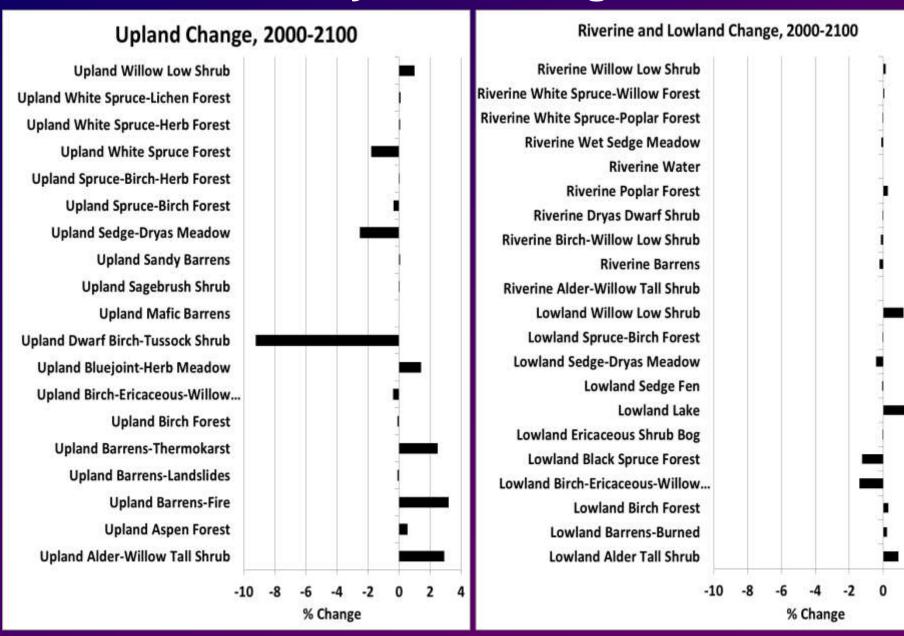


### Modeling Change with Transition Probabilities

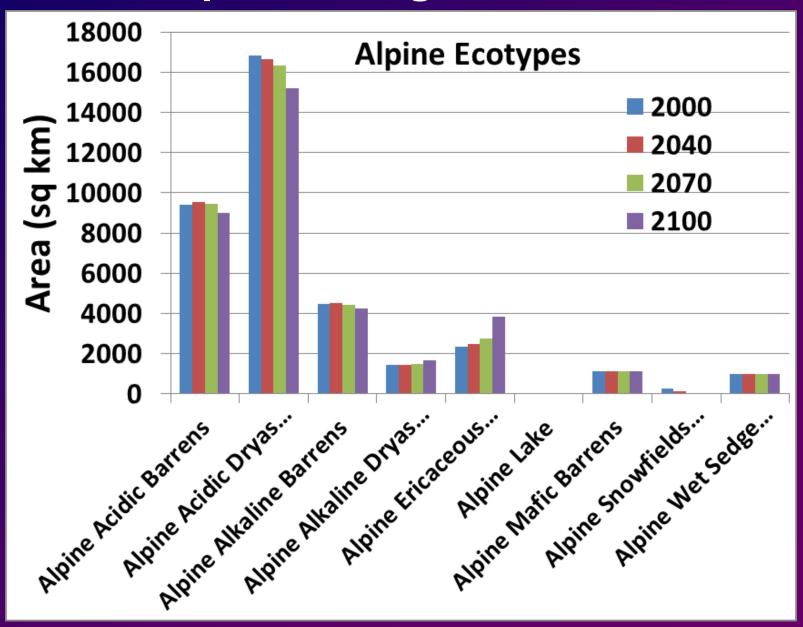


Alpine glaciers high sensitivity with positive feedbacks, 2x Riverine tall shrub, low sensitivity dominated by numerous other factors, 0.5x

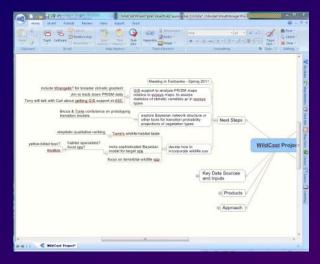
### Predicted Ecosystem changes, 2000-2100



## Alpine Changes, 2000-2100



# Bayesian Network Modeling



#### **Factors**

alder proximity, seed production, seed establishment, growth rate, soil drainage

#### **Transition**

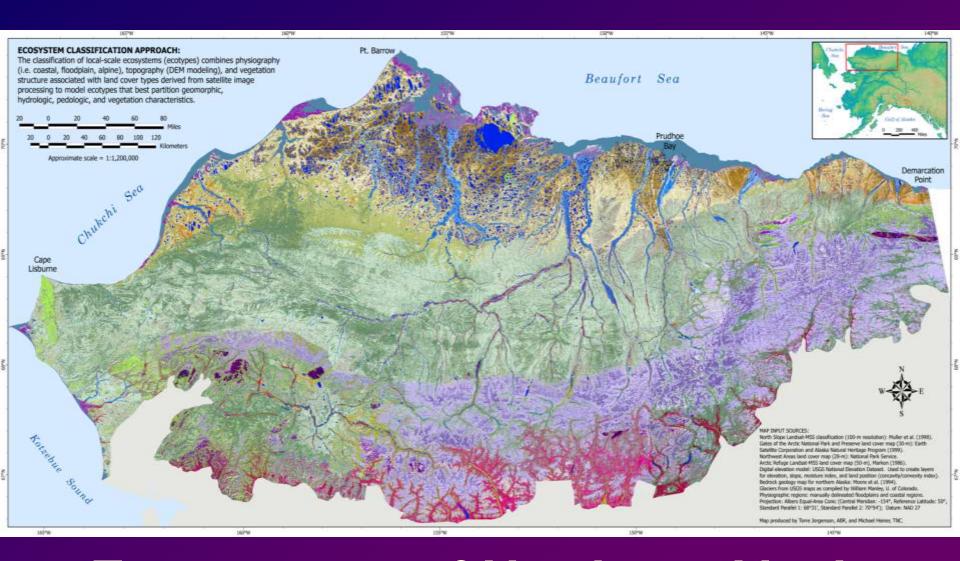
Upland
Dwarf BirchTussock
Shrub

Upland Dwarf Birch-Tussock Shrub
Upland Birch-Ericaceous Low Shrub
→ Upland Alder-Willow Tall Shrub ←
Upland White Spruce Forest
Upland Barrens-Burned
Upland Barrens-Thermokarst
Lowland Lake
Coastal Water
Human Modified Barrens

#### Driver

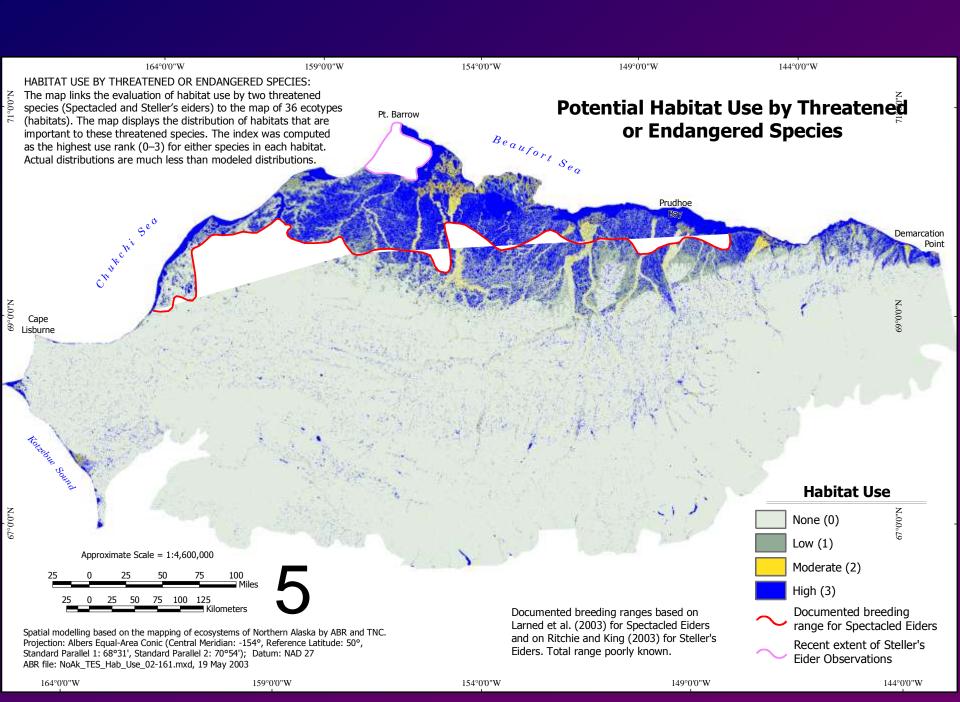
None
Dominance shift
Plant migration ←
Drainage/Migration
Fire
Thaw Slump
Thaw Lakes
Coastal erosion
Human development

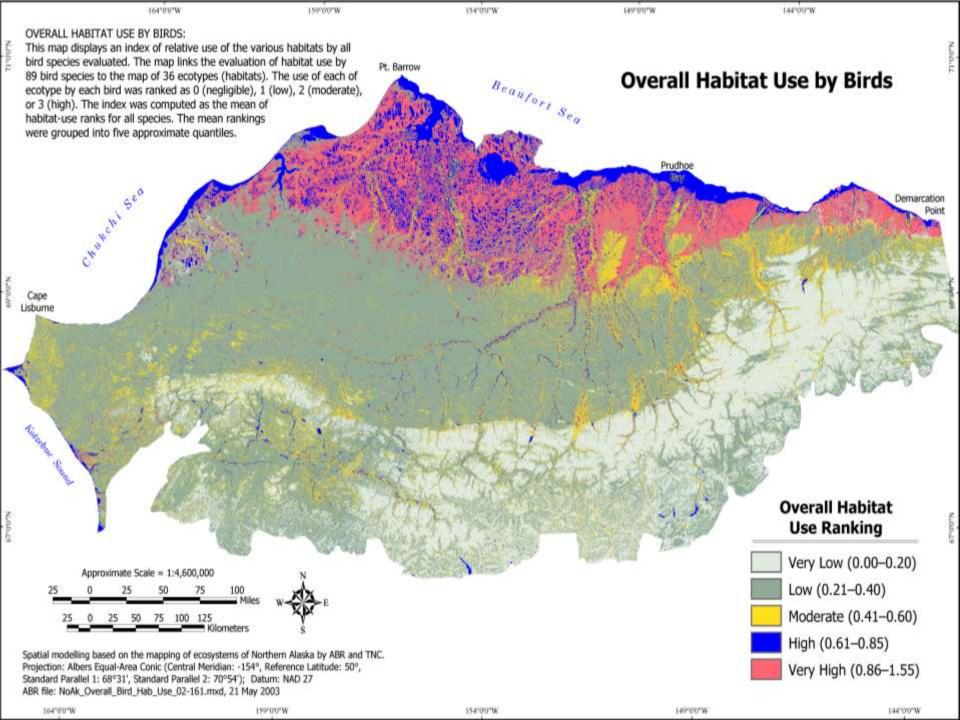
### From Habitats to Habitat Use

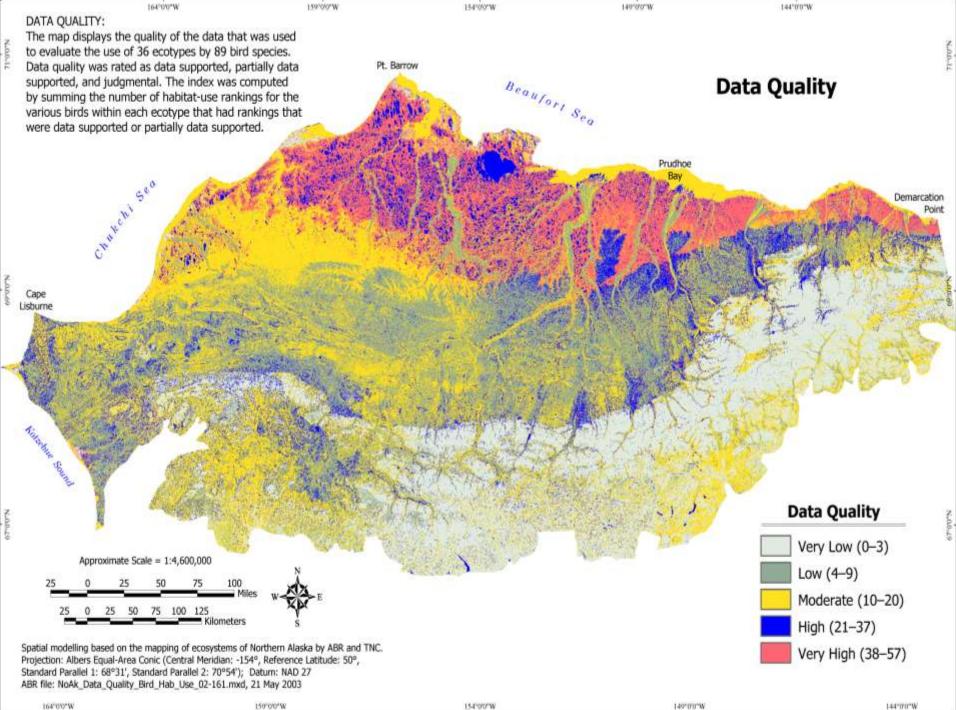


## **Ecosystems of Northern Alaska**

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1	- н	B Preliminary ranking of habitat use for													R S	<u> </u>	U	V	W	X Y	4	нн /	MB M	LAD	HE	MF M	GAR	1 HI	HJ /	4K H	LHIV	HIN	HUH	HL	Į AK	HO H	41 MU	JAVA	AW H	XIA-
2		Use ranks are 0 = none/negligible, 1 = low, 2														.ld =	المامة				+		-	+		-	+	+		-	+		-	+		-	-	$\vdash$	+	+
3		regular = partially data-supported, &alics =															uau	a-su	ppor	ieu,	+		-	+		-	+	+		_	+			+					+	+
4		Species names with "indicate major subsist				loid .	Spec	/IE3 I1	iaille.	,-,-	nge ii	IIICEC	11011	1113 3	pecie	· 5.			_	+	+		_			_	+			_	+		_	+			_		+	+
5		opeoles hames with major subsis-		ecie:		hal	hatir	al c	vrdor	1		+				_											+												+	+
6											BL B	BI BI	I BB	BB	CAIC	dec	- 00	CC	CC E	LLEC	n GL	GC	er e	E GV.	GV.	GVH	ΔН	KIE	KINI	ΔΠ	FILE	1E	IBT.	пт	Ма	NC N	ac No	NC	NC P	C P
Ť			1			-11	1		// 55	-		0, 0,				-	100	-		~	100	-	-	w	-	<u> </u>	11.0	1 (12	1 (11)					.,	1		-	110	•	7
7	Map Valu	Ecotype	American Dipper	American Golden-Plover	American Pripir American Tree Sparrow	American Wigeon"	Arctic Tern	Baird's Sandpiper	Black Guillemot	Black Scoter	Black Turnstone	Bluethroat	Brant*	Buff-breasted Sandpiper	Canada Goose"	Common Loon	Common Raven	Common Redpoll	Common Snipe	Fox Sparrow	Glaucous Gull	Golden Eagle	Gray-cheeked Thrush Greater Scaun	Greater White-fronted Goos	Green-winged Teal	Gyrfalcon Hadomin Duck	Hoary Redpoll	King Eider*	Kittlitz's Murrelet	Lapland Longspur	Lesser Scaup*	LesserYellowlegs	Long-billed Dowitcher Long-tailed Duck*	Long-tailed Jaeger	Mallard"	Northern Harrier	Northern Shoveler	Northern Shrike	Northern Wheatear Pacific Golden Plover	Pacific Lon
9	41	Alpine Glaciers	0	0 .	00	0	0	0 1	0 0	0	0 .	0 0	10	0	0 6	20	0	0	0 1	0 0	0	0	0 6	10	0	0 6	2 0	0	0	0 6	10	0	00	0	0	0	0 0	0	00	0 4
10	43	Alpine Noncarbonate Barrens	0	7	10	0	0	0	0 0	0	0	0 0	0	0	0 0	0	1	0	0	0	0	0	0 0	0	0	0 0	7 0	0	2	0 6	0	0	00	0	0	0	00	0	2 1	0 6
11	44	Alpine Carbonate Barrens	0	1	10	0	0	0 8	0 0	0	0 .	0 0	0	0	0 1	0	1	0	0 6	0	0	0	0 0	10	0	0 1	7 0	0	2	0 0	0	0	00	0	0	0	0 0	0	2 0	0 1
12		Alpine Mafic Barrens	0	0	0 0	0	0	0 0	0 0	0	0 .	0 0	0	0	0 6	0	0	0	0 6	0	0	0	0 6	0	0	0 1	7 0	0	2	0 6	7 0	0	00	0	0	0	0 0	0	0 6	0 1
13		Alpine Noncarbonate Dwarf Shrub Tundra		2	10	0	0	1	10	0	0 .	0 0	0	0	0 1	7 0	1	0	0 6	0	0	1	0 6	0	0	1 6	7 0	0	0	1 6	0	0	0 0	7 1	0	0	0 0	0	1 6	2 6
14		Alpine Carbonate Dwarf Shrub Tundra	0	2	10	0	0	1	10	0	0 .	0 0	0	0	0 1	20	1	0	0 0	0	0	1	0 0	0	0	0 1	7 0	0	0	1 6	0	0	00	7 1	0	0	00	0		0 4
15		Alpine Mafic Dwarf Shrub Tundra	0	3	10	0	0	1	1 0	0	0 .	0 0	0	0	0 0	20	1	0	0 0	2 0	0	2	0 0	0	0	1 4	7 0	0	0	1 6	7 0	0	0 0	1	0	0	0 0	0	1 6	0 4
16		Alpine Lake (now included in Lowland Lake		0	0 0	1	7	0 1	0 0	0	0 .	0 0	7 0	0	0 1	2 /	0	0	0 1	2 0	0	0	0 0	7 0	0	0 0	2 0	0	0	0 0	7 0	0	0 0	0	0	0	0 0	0	00	2 4
17		Upland Spruce Forest	0	0	0 7	0	0	0 0	0 0	0	0 1	0 0	7 0	0	0 0	7 0	7	0	0 0	7 0	0	0	3 6	7 0	0	0 0	7 0	0	0	0 0	7 0	0	0 0	0	0	0	0 0	0		0 4
18		Upland Birch-Aspen-Spruce Forest	0	0 1	0 7	0	0	0 1	0 0	0	0 1	0 0	7 0	0	0 0	7 0	7	0	0 1	9 0	0	0	0 0	7 0	0	0 0	7 0	0	0	0 0	/ //	0	0 0	0	0	0	0 0	0	0 0	0 4
19 20		Upland Birch-Aspen Forest	0	0 1	0 7	0	0	0 0	0 0	0	0 1	0 0	2 0	0	0 0	0	7	0	0 0	0 0	0	0	0 0	2 0	0	0 0	2 0	0	0	0 0	2 0	0	0 0	0	0	0	0 0	0	0 0	44
21		Upland Tall Alder Shrub Upland Low Birch-Willow Shrub Tundra	0	1	0 3	0	0	0 0	1 0	0	0 1	0 2	2 0	0	0 0	2 0	0	2	0 0	$\frac{2}{2}$	0	0	3 6	7 0	0	0 0	$\frac{7}{3} + \frac{2}{3}$	0	0	1 0	2 0	0	0 0	2 7	0	0	0 0	3	0 0	0 4
22		Upland Dryas Dwarf Shrub Tundra	0	1 1	0 2	0	0	1	2 0	0	0 1	7 0	3 0	1	0 0	2 0	0	0	0 0	$\frac{2}{a}$	0	0	$\frac{1}{a}$	7 7	0	0 0	$\frac{7}{2} \frac{2}{0}$	0	0	2 6	2 0	0	0 0	7 7	0	1	0 0	0	20	44
23		Upland Shrubby Tussock Tundra	0	1	0 0	0	0	7	1 0	0	0	0 0	2 0	7	0 0	2 2	0	2	7 1	7 7	1 0	0	1 /	7 1	0	1 1	7 2	0	0	1 /	2 0	0	1 6	7 1	0	1	0 0	7	0 0	0 2
24		Upland Tussock Tundra	0	1	0 0	0	0	7	1 0	0	0	0 0	7 0	1	0 1	7 0	0	0	1	1 0	7	0	0 1	7 1	0	1 /	2 2	0	0	2 /	2 0	0	1 .	1 7	0	7	1 0	10		0 2
25	35	Upland Moist Sedge-Shrub Tundra	0	2	0 0	0	0	1	1 0	0	0	1 7	7 17	3	0 1	7 0	0	1	2	2 0	10	0	0 1	7 7	0	0 1	7 1	1 1	0	2	1 0	0	1 .	1 2	0	1	0 0	0	1 7	2 1
26		Upland Bluffs (not mapped)	0	0	0 0	0	0	1	9 0	0	0	0 0	7 11	17	0 1	2 0	0	'n	0 1	2 0	0	3	0 1	7 0	0	3 /	2 1	0	0	0 1	7 0	0	0 0	1 2	0	0	0 0	0	0 7	2 7
27	28	Lowland Spruce Forest	0	0	0 0	0	0	0	0 0	0	0	0 0	7 0	0	0 6	20	1	0	2 4	0 0	0	0	1 4	7 0	0	0 6	2 0	0	0	0 0	7 0	0	0 0	0	0	0	0 0	0	0 1	0 2
28		Lowland Spruce-Birch Forest (not mapped	0	0	0 1	0	0	0	1 0	0	0	0 0	10	0	0 0	20	1	1	0 6	0	0	0	0 0	10	0	0 0	7 0	0	0	0 0	10	0	0 0	0	0	0	0 0	0	01	2 6
29		Lowland Birch Forest (not mapped)		0 .	0 1	0	0	0 1	0 0	0	0 .	0 0	7 0	0	0 0	0	1	0	0 6	0 0	0	0	0 0	10	0	0 0	7 0	0	0	0 0	10	0	0 0	0	0	0	0 0	0	0 6	2 6
30		Lowland Low Birch-Willow Shrub	0	1 .	00	0	0	0 1	0 0	0	0 .	0 0	10	0	0 6	20	0	2	0 1	0 0	1	0	0 6	7 2	0	0 6	2 1	0	0	2 6	10	0	00	0	0	0	0 0	0	0 6	2 6
31	25	Lowland Moist Sedge-Shrub Tundra	0	3 .	0 0	0	2	3	2 0	0	2	3 0	7 1	3	3 4	7 0	0	1	1 :	3 0	2	0	0	1 2	2	0 6	7 1	1 2	0	3	2 0	0	3 2	2 3	0	7	3 /	0	1 2	2 :
32		Lowland Wet Sedge Tundra	0	3	0 0	2	2	2	3 0	0	0	3 6	7 3	3	2 2	2 0	0	1	3	3 0	2	0	0	1 3	2	1 4	7 1	3	0	3	2 1	1	3 3	3	2	1	3 2	0	0 6	2:
33	22	Lacustrine Barrens (drained lakes, not map		1 4	0 0	0	7	0 0	0 0	0	0	1 0	7 2	0	1 6	7 0	0	0	0	10	1	0	0 6	0	0	0 6	7 0	7	0	0 6	7 0	0	0 0	0	0	0	0 0	0	0 0	7 4
34		Lacustrine Marsh (not mapped)	0	1 4	0 0	0	1	0 0	0 0	0	0 .	0 0	7 3	1	2 1	0	0	0	2	1 0	2	0	0 2	3	2	0 1	7 0	3	0	0 6	7 0	0	2 3	3 7	1	0	3 /	0	0 0	2 :
35		Lowland Lake	0	1 .	0 0	2	2	0 1	0 0	0	0 .	0 0	7 3	1	2	1 1	0	0	0	1 0	3	0	0 2	2 3	2	0 0	7 0	2	0	1 6	/ 2	0	1 3	3 0	2	0	2 2	0	0 0	7 :
36		Riverine Spruce Forest	7	0	0 1	0	0	0 0	0 0	0	0 .	0 0	0	0	0 0	7 0	1	0	0 0	9 0	0	0	0 0	0	0	0 1	7 7	0	0	0 0	0	7	0 0	0	0	0	0 0	0		0 4
37		Riverine Spruce-Balsam Poplar Forest	7	0 1	0 1	0	0	0 0	0 0	0	0 1	0 0	1 0	0	0 0	0	7	0	0 0	9 0	0	0	0 0	0	0	0 1	/ /	0	0	0 0	2 0	2	0 0	0	0	0 .	0 0	0	0 0	0 4
38		Riverine Balsam Poplar Forest	0	0 1	0 7	0	0	0 0	0 0	0	0 1	0 0	2 0	U	0 0	2 0	1/2	0	0 0	2 0	0	0	0 0	1 0	0	0	1 0	10	0	0 6	2 0	0	0 0	2 0	0	0	0 0	0	0 0	44
39 40		Riverine Tall Alder-Willow Shrub	7	<i>U</i> 4	0 2	0	0	0 0	0 0	0	0 1	0 2	0 0	0	0 6	7 0	0	2	0 0	2 2	0	0	1 6	1 0	U	0 2	2 2	0	0	0 6	2 0	0	0 0	2 0	0	0	0 0 1 0	1	0 0	44
40		Riverine Low Willow Shrub Tundra Riverine Dryas Dwarf Shrub Tundra	0	1 4	9 <b>3</b>	0	0	0 0	1 0	0	0	$\frac{g}{2}$	2 0	0	0 4	2 0	0	0	1 6	7 3	1 1	0	3 6	7 1	0	$\frac{1}{2}$	2 0	0	0	7 2	2 0	0	0 0	2 2	0	2	0 0	3	3 0	0 4
42		Riverine Dryas Dwarr Shrub Tundra Riverine Moist Sedge-Shrub Tundra	0	1 1	0 0	0	0	0 1	0 0	0	0	1 0	7 1	0	1 1	7 0	0	0	1 1	0 0	1 1	0	$\frac{\sigma}{\sigma}$	7 1	1	0 6	7 0	1	0	3 6 1 2	2 1	0	0 0	7 2	0	7	0 0	0	0 0	0 2
43		Riverine Wet Sedge-Shrub Tundra	0	1 .					0 0		_	1 0			1 6		0	_	7 3			_	0 2	2 2	1		7 0	-		7 2			0 2				2 2		0 0	
44		Riverine Marsh (not mapped)								-					2 6											-				-						-	_	-	_	
45		Riverine Barrens		0								1 0			1 6							0		7 0			7 0			1 4			1 0						0 0	
46		Riverine Waters	$\rightarrow$	0		-		-		-	-	0 0			1 6				-				-	1 7			3 0		0						7	_			00	
47		Coastal Barrens		0								2 0				3 0				2 0				1 0			1 0				2 0	0	2 2				20		0	
48		Coastal Grass and Dwarf Shrub Tundra	0	-	0 0	-		-		-					0			1		10			0		-	-	2 0		0	-			-	10		-	0 0		0 0	
49		Coastal Wet Sedge Tundra													1																	_	2 2	_	_			_		
50		Coastal Water		0									7 2									0		2 1			7 0		1		0			3 7					00	
51		Marine Water (not mapped)	0	0	$a \mid a$	17	1	11	7 3	2	0	0 0	7 1	17	11 2	2 0	17	17	11 1	9 0	1	17	01	0	17	0 1	2 0	1	2	0 1	7 17	0	0 3	1 1	0	0	$a \mid a$	0	0 0	0
52		Human Modified	0	1 4	00	0	1	1 4	2 <b>1</b>	0	0 .	0 0	7 0	0	0	10	2	0	0 6	0	1	0	0 6	0	0	0 6	7 0	0	0	0 6	10	0	00	0	0	0	0 0	0	0 6	2 L
53	N	0::1::								$\perp$					,				I																					
<b>I</b>	P   P	Original pivot Ranking table - s	peci	es a	ıpna	Λ.	Kar	iking	g tab	ıe -	spec	ies t	raxo	П,	/																			1						P







### **FUTURE EFFORTS**

- Refine transition probabilities with additional data compilation
- Develop proto-type spatial model for few select ecotypes
- Predict bird and mammal responses based on habitat availability